

6.6 MODEL REPRESENTATION OF THE AMBIENT ELECTRON DENSITY DISTRIBUTION IN THE MIDDLE ATMOSPHERE

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While the Langmuir probe controlled by rocket propagation experiments by the University of Illinois at midlatitude revealed the existence of a permanent D-region turning point (DTP), similar measurements over the Thumba equatorial station did not clearly bring out the above daytime feature. Moreover, the calibration constant (ratio of electron density to the current drawn by the Langmuir probe) increased with height (in the 70-100 km region) in the case of the midlatitude observations whereas the recent measurements over Thumba showed a decrease up to about 90 km followed by an increase above 90 km. Secondly, there is the problem of reconciling the station-oriented observations from the COSPAR family with the ground-based radio propagation measurements from the URSI family. Thirdly, new information on Winter in Northern Europe (WINE) and in USSR is available by asking for its incorporation into any global model such as the IRI. This paper presents the results of investigation of the above aspects.

The new analytical description of the electron-density profile in the lower ionosphere envisages the use of the LAY-function which is associated with three nonlinear, geometric parameters. Setting aside the question of a C-layer, three such functions are envisaged; thus, apart from the E-peak data which are used as nodal points, nine geometric parameters are needed to represent the lower ionosphere. Numerical values for noon, night, morning and evening twilight were given by Ramanamurty and Rawer. It is proposed to find the coefficients in a linear combination of the three functions by an optimization procedure inside the IRI program itself.

In order to reach this goal, characteristic features (points or derivatives) of the profile must be known. To that end, we have carefully studied measured profiles from different latitudes. Unfortunately, there are only a few sets of systematic measurements over longer times. These were obtained with different techniques. In the following we consider and compare the (Wallops) series of northern midlatitude profiles published by Mechty et al. [1972] and that of Subbaraya et al. [1983] for a station near the dip equator (Thumba). Both sets were obtained with Langmuir probe measurements, the first one being checked by ground-to rocket propagation experiments.

The crucial problem with Langmuir probes is calibration. While it could be resolved by the Mechty group with point-by-point propagation data, the Subbaraya group had to rely on other evidence. On one occasion (3 March 1973) they flew an in situ resonance probe for comparison. The result is shown in Figure 1a where Mechty's calibration is shown below 95 km. This latter, after some height shift, was matched with the direct calibration (at greater heights) so that the calibration factor increased monotonically with height. In a subsequent publication one of the Indian authors assumed the factor to be constant in the 60 to 100 km height range. Another calibration obtained by comparing with differential wave absorption (1987) led to a height dependence with a clear minimum near 90 km (Figure 1b).

In order to check the quality of the data, the density ratio between high ($F = 135$) and low ($F = 50$) solar activity was plotted as a function of height (Figure 2). It shows rather strange variations. For comparison, the electron production rate taken from theoretical consideration [Deshpande et al.] was dealt with in the same manner and plotted in the same figure. Both curves compare rather poorly. Also, the very small value of the probe curve at 90 km is difficult to understand.

Finally, we show the maximum/minimum density ratio in Figure 3 in more detail. Above 63 km the Wallops data show a ratio greater than one, as expected. The variation with height, when averaged, has a simple shape with a maximum near 80 km. Quite different, the Thumba data show several maxima and minima and ratios less than one between 85 and 95 km.

We conclude that Langmuir probe measurements of electron density in the middle atmosphere should not be accepted unless they are accompanied by simultaneous radio wave propagation experiments.

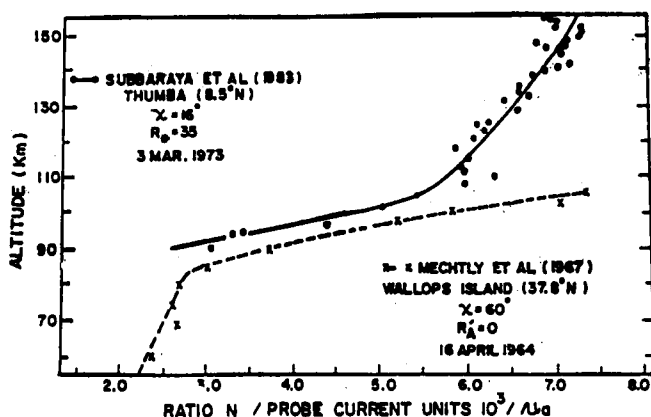


Figure 1. Top curve: in most of the experiments conducted by the Physical Research Laboratory (PRL), Ahmedabad, India, only the Langmuir probe experiment was flown. On 3 March 1973 when the Langmuir probe was calibrated by in situ resonance probe, the variation of the calibration factor, F (the ratio of the electron density, N) measured by resonance probe to the current, I , drawn by the Langmuir probe is shown above. Note that F changes drastically above 90 km. Bottom curve: The height variation of F inferred by Subbaraya et al. [1983] from the results of Mechtly et al. [1967] is shown. The calibration factor F , inferred by Subbaraya et al. [1983] is an ever increasing function of height in the 60 to 100 km region, whereas it is more or less constant below 85 km, according to Mechtly et al. [1967].

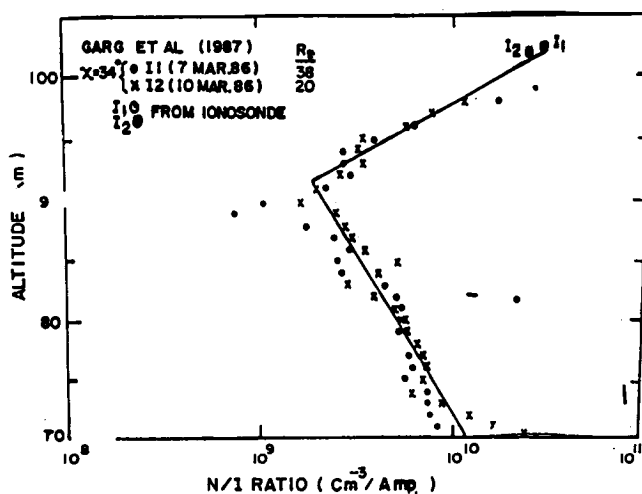


Figure 2. Thumba: N = electron density obtained from absorption experiment flown in rocket. I = current drawn by Langmuir probe flown in the same rocket. Note that N/I decreased up to 90 km by about an order of magnitude.

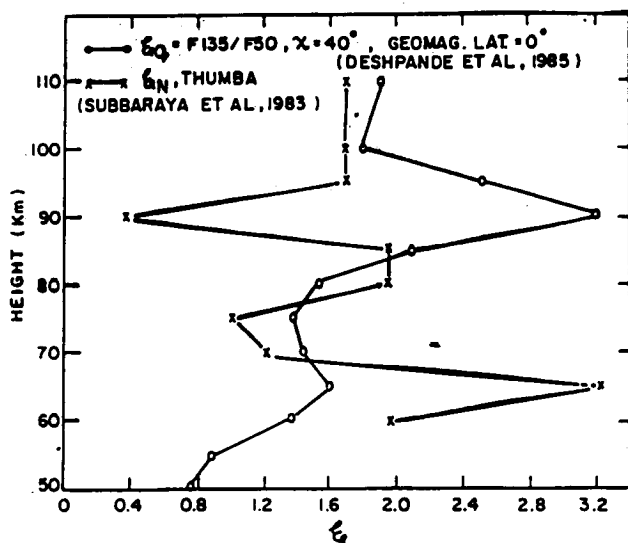


Figure 3.

q = rate of ion production at a particular height

q_{\max} = q at solar maximum

q_{\min} = q at solar minimum

$$\xi_q = \frac{q_{\max}}{q_{\min}}$$

N = electron density at a particular height

$$\xi_N = \frac{N_{\max}^2}{N_{\min}^2}$$

ξ_q was based on the work of Deshpande et al. [1985]. ξ_N was derived from the results of Langmuir probe experiments reported by Subbaraya et al. [1983]. ξ_q and ξ_N are expected to synchronize with each other. Results do not confirm. They are sometimes anticorrelated. Also, ξ_N was less than unity around 90 km (the ledge region) which is not acceptable.

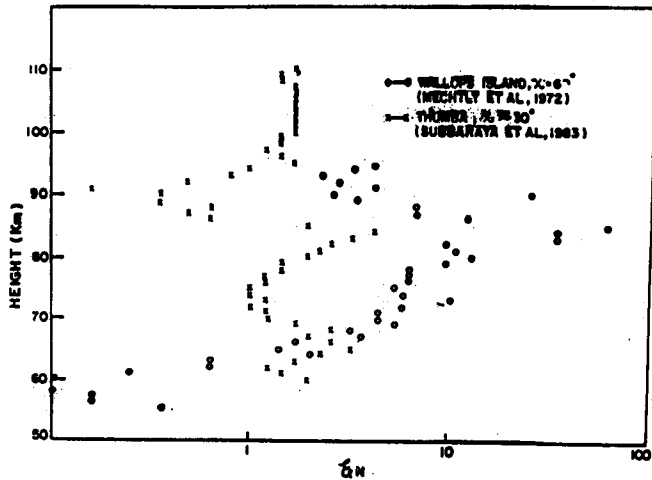


Figure 4. ξ_N for Thumba and Wallops Island are compared. The height variation of ξ_N does not synchronize at Thumba and Wallops Island.

CONCLUSIONS

- The past in situ D-region measurements (especially those involving electron-density measurements by the Langmuir probe technique only) have to be re-evaluated in the light of the discrepancies with the measurements over Wallops Island where in situ calibration of Langmuir probe measurements is done.
- The tentative model representation of the lower ionosphere discussed by Ramanamurty and Rawer [1987] is proposed for the present.
- In future, use of Langmuir probe-cum-propagation experiments is recommended to obtain the necessary data base at different latitudes.